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Entomological Diversity of Ethiopia: Species Richness, Lepidopteran Diversity, Agricultural Insects and Priorities for Species-Level Research

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Abstract

Ethiopia contains exceptionally diverse landscapes ranging from Afro-montane highlands and forests to dry lowlands, savannas and intensively cultivated agricultural systems. These environmental gradients support a diverse insect fauna with major ecological, agricultural and conservation importance. This review examines Ethiopian entomology at species level, with particular emphasis on Lepidoptera as a relatively well-documented indicator group, while also considering economically important agricultural insects and post-harvest pests. A published national review recorded 2,438 Lepidoptera taxa in 48 families, including 664 endemic taxa, demonstrating both high diversity and substantial taxonomic distinctiveness. More recent field research at Wolaita Sodo University documented 50 day-flying Lepidoptera species from six families during 2022–2023, illustrating how local inventories can reveal substantial diversity even within relatively small landscapes. Agricultural entomology adds a second dimension: invasive and damaging species such as the fall armyworm, Spodoptera frugiperda, have become important maize pests in Ethiopia, while diverse storage insects affect staple and export crops after harvest. The review synthesizes species richness, habitat associations, agricultural importance, identification methods and research gaps. Results indicate that Ethiopia requires stronger integration of classical taxonomy, specimen-based collections, DNA barcoding, ecological monitoring, geospatial analysis and farmer-oriented integrated pest management. A national species-level entomology strategy would improve biodiversity documentation while strengthening early detection and management of invasive and economically important insects.

Keywords: Ethiopia; entomology; insect species; Lepidoptera; butterflies; moths; insect biodiversity; endemic species; agricultural pests

1. Introduction

Ethiopia is characterized by strong environmental heterogeneity. The country's central highlands, Rift Valley, dry lowlands, forests and agricultural landscapes create a mosaic of habitats that can support distinct insect assemblages. The country's highland geography is also associated with considerable endemism in flora and fauna [1]. Consequently, Ethiopian entomology has two complementary priorities: documenting biodiversity and understanding insects that affect agriculture, livestock, stored products and ecosystem functioning.

Lepidoptera provide an especially useful entry point because butterflies and moths are taxonomically diverse, ecologically heterogeneous and represented in both natural and agricultural habitats. A comprehensive review published in ZooKeys reported 2,438 Ethiopian Lepidoptera taxa in 48 families, of which 664 were endemic; the authors also emphasized that the inventory remained incomplete [1]. This combination of high documented richness and known incompleteness indicates that the Ethiopian fauna remains a substantial taxonomic research opportunity.

Local inventories continue to add important information. A 2024 study at Wolaita Sodo University recorded 50 day-flying Lepidoptera species representing six families from four microhabitats during January 2022–December 2023 [2]. Such studies show why national checklists should be complemented by standardized local sampling across elevations, seasons, land-use types and protected areas.

Agricultural entomology introduces a different but connected challenge. The fall armyworm, Spodoptera frugiperda, was first reported in Ethiopia in 2017 and subsequently became an important pest of maize [3]. Post-harvest insect pests also affect major food and export crops, and a recent Ethiopian case-study review described cultural practices, botanicals, resistant varieties, improved storage and entomopathogenic fungi among management approaches [4].

A species-level perspective can connect these fields. Correct identification is essential for biodiversity inventories, invasive-species surveillance, pest diagnosis, biological-control programs and ecological research. Misidentification can lead to incorrect distribution records and inappropriate pest-management decisions. This manuscript therefore emphasizes species-level documentation as a foundation for both conservation entomology and agricultural pest management.

2. Objectives

To synthesize evidence on insect-species diversity in Ethiopia, using Lepidoptera as the principal biodiversity case study.
To describe the ecological and agricultural significance of selected Ethiopian insect species and groups.
To review practical methods for species-level collection, identification and validation.
To identify major gaps and priorities for future Ethiopian entomological research.

3. Method

This manuscript is a narrative review rather than a systematic review or meta-analysis. Peer-reviewed literature and authoritative biodiversity or agricultural databases were searched using combinations of the terms Ethiopia, insect, entomology, species diversity, Lepidoptera, butterflies, moths, agricultural pests, fall armyworm, storage pests, taxonomy and DNA barcoding. Priority was given to studies providing species-level records, national or regional inventories, quantitative diversity data, or documented agricultural relevance. Evidence was organized into four themes: (1) species richness and endemism, (2) habitat and geographic patterns, (3) agricultural and

post-harvest insects, and (4) species-identification and monitoring methods. Reported numerical findings were extracted from the cited publications and are not original field observations. The figures are original conceptual diagrams prepared for this manuscript.

4. Results

4.1 National and Regional Species Diversity

The strongest quantitative baseline located for Ethiopian insect biodiversity concerns Lepidoptera. Tujuba et al. [1] compiled 2,438 taxa in 48 families and identified 664 endemic taxa. The review also reported 929 taxa that had been described from type specimens collected in Ethiopia. The authors cautioned that the inventory was still incomplete, indicating that the recorded total should be treated as a documented baseline rather than a definitive national richness estimate.

The 2024 Wolaita Sodo University study provides a useful example of finer-scale sampling. Across four microhabitats, researchers recorded 50 species and 367 individuals, distributed across six Lepidoptera families [2]. Nymphalidae was the most represented family in that study, with 31 species. The study also demonstrated the value of comparing microhabitats because species abundance and composition varied among sampling environments [2].

4.2 Species Richness and Endemism

The 664 endemic Lepidoptera taxa reported by Tujuba et al. [1] represent approximately 27% of the 2,438 taxa compiled in that review. This is a notable proportion and supports the interpretation that Ethiopia's topography and habitat heterogeneity have generated substantial biogeographic differentiation. Endemism is particularly important for conservation because species with restricted distributions may be more vulnerable to habitat conversion, climate change, fire, invasive plants and other disturbances.

The high number of taxa described from Ethiopian type localities also demonstrates the historical importance of the country to taxonomic discovery [1]. However, historical type-locality records do not necessarily indicate that a species is currently widespread or secure. Contemporary surveys and repeated sampling are required to distinguish persistent populations from historical records.

4.3 Habitat and Altitudinal Gradients

Ethiopia's insect fauna is shaped by strong climatic and topographic gradients. The country includes montane environments, highland agricultural landscapes, dry lowlands and forest habitats, producing substantial differences in host plants, temperature, rainfall and seasonality [1]. Lepidopteran assemblages consequently vary geographically and among habitat types.

For species-level studies, altitude should be treated as an important sampling variable. Sampling only around major cities or easily accessible agricultural areas can underrepresent montane specialists, forest-associated taxa and species occurring in remote lowlands. A national inventory should therefore stratify sampling by elevation, habitat and season.

4.4 Agricultural Insect Species: Fall Armyworm

Spodoptera frugiperda, the fall armyworm, became established as an important maize pest in Ethiopia after its detection in 2017 [3]. A review of Ethiopian infestations reported extensive occurrence across major maize-growing regions and highlighted the pest's capacity to cause serious damage under favorable conditions. The

species illustrates the importance of rapid taxonomic confirmation, surveillance and integrated management following invasive-species introduction.

Management should not rely exclusively on repeated insecticide applications. Species-specific integrated pest management can combine scouting, agronomic practices, resistant or tolerant varieties where available, biological control, conservation of natural enemies and selective chemical intervention when economic thresholds are exceeded [3].

4.5 Post-Harvest and Stored-Product Insects

Stored-product entomology is another major component of Ethiopian agricultural entomology. A 2022 review documented important insect pests associated with staple and export crops and evaluated cultural practices, botanicals, varietal tolerance, storage structures and entomopathogenic fungi as management approaches [4]. The review emphasized that many interventions have been investigated under local conditions but that additional work is needed to translate experimental results into robust farmer-ready technologies.

Species-level identification is especially important in stored-product systems because pest biology determines where and when control should occur. Monitoring should therefore distinguish field infestation from storage infestation and should document commodity, storage structure, moisture conditions, duration of storage and pest abundance.

4.6 Species Identification and Taxonomic Validation

Classical morphological identification remains essential because specimens provide permanent evidence that can be deposited in reference collections. However, morphology can be difficult for cryptic species, immature stages, damaged specimens and closely related taxa. DNA barcoding can complement morphology by providing standardized sequence data and helping link life stages when validated reference sequences are available [1].

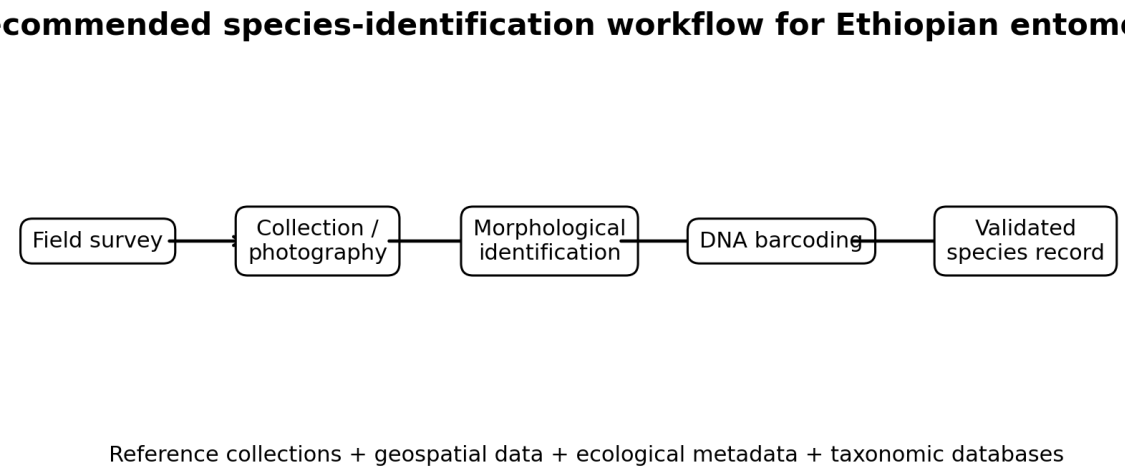


Figure 2. Recommended species-identification workflow combining field sampling, morphology, DNA evidence and curated reference collections. Original figure.

4.7 Ecological and Agricultural Functions

Ethiopian insects occupy diverse functional roles. Lepidopteran adults may contribute to pollination, while larvae participate in herbivory and food webs. Other insect groups provide predation, parasitism, decomposition and nutrient cycling. At the same time, herbivorous species can become agricultural pests when their populations exceed crop tolerance. The same broad ecological diversity that makes insects valuable biodiversity components therefore also creates a large pool of potential crop-associated species.

A species-focused approach should document both positive and negative functions. Natural enemies should be recorded during pest surveys rather than treated as incidental observations, because their abundance and diversity can influence the outcome of integrated pest management.

Table 1. Selected Ethiopian insect groups and species-level research priorities

Group/species	Importance	Primary research need	Recommended method
Lepidoptera	Biodiversity, herbivory, pollination, conservation	National and regional inventories; endemic-species monitoring	Transects, light traps, host-plant records, morphology + DNA
Spodoptera frugiperda	Major maize pest	Distribution, resistance monitoring, natural enemies	Field scouting, pheromone traps, molecular confirmation
Stored-product beetles/moths	Post-harvest losses	Commodity-specific abundance and control	Sampling of stored commodities, morphological identification
Predatory insects	Natural pest regulation	Role in IPM and landscape ecology	Sweep-net, pitfall and visual sampling
Parasitoid wasps	Biological control	Host associations and mass-rearing potential	Host rearing, taxonomic and molecular identification
Pollinating insects	Crop and wild-plant pollination	Seasonal abundance and crop visitation	Transects, pan traps, direct observation

Table 2. Quantitative findings reported by Ethiopian studies

Source	Reported result	Significance
Tujuba et al. [1], national Lepidoptera review	2,438 taxa; 48 families; 664 endemic taxa	Major baseline for Ethiopian Lepidoptera
Tujuba et al. [1]	929 taxa were described from type specimens collected in Ethiopia	Demonstrates historical taxonomic importance
Wendimu et al. [2], Wolaita Sodo University	50 species; 367 individuals; 6 families; sampling during 2022–2023	Shows substantial local diversity and value of microhabitat sampling
Wendimu et al. [2]	Nymphalidae accounted for 31 of the 50 recorded species	Indicates strong family-level differences in local richness
Assefa & Ayalew [3]	Fall armyworm became an important maize pest after its 2017 introduction	Illustrates invasive-pest surveillance need

Table 3. Priority components of a national Ethiopian insect-species program

Component	Core activity	Expected output
Reference collections	Curate voucher specimens with locality and date	Verified national taxonomic archive
DNA barcoding	Sequence representative and difficult	Linked molecular reference library

	taxa	
Geospatial monitoring	Map records by elevation, habitat and land use	Species-distribution datasets
Agricultural surveillance	Monitor pest and natural-enemy species	Early-warning and IPM information
Long-term ecological plots	Repeat standardized sampling	Trend data on abundance and phenology
Capacity building	Train taxonomists and agricultural entomologists	Sustained national expertise

5. Discussion

The literature supports a dual interpretation of Ethiopian entomology. First, Ethiopia is a major reservoir of insect diversity that remains incompletely documented. Second, insect species are directly connected to agricultural productivity through herbivory, post-harvest losses and biological control. These two perspectives should not be separated. The same landscapes that conserve biodiversity can also provide natural enemies and pollinators that support agriculture.

The Lepidoptera evidence is particularly compelling. The documented national total of 2,438 taxa and 664 endemic taxa [1] provides a strong baseline, but the incompleteness of the inventory means that absence from published records should not be interpreted as true absence. Recent local surveys [2] continue to identify substantial diversity, supporting broader and more standardized sampling.

Agricultural pest research demonstrates a different urgency. The arrival and spread of S. frugiperda show how quickly a non-native insect can become a major crop-management issue [3]. The appropriate response requires accurate identification, distribution monitoring, resistance management and conservation of natural enemies. Stored-product research similarly requires species-level diagnosis because control measures depend on pest biology and storage conditions [4].

A major methodological opportunity is integration of morphology and molecular approaches. DNA barcoding should not replace taxonomy; rather, it can complement specimen-based identification. Reference sequences are only useful when linked to correctly identified voucher specimens. Ethiopian institutions would therefore benefit from coordinated specimen repositories, standardized metadata and interoperable digital databases.

Climate change adds another layer of complexity. Changes in temperature, rainfall and vegetation can shift insect phenology and geographic distributions. Long-term monitoring across elevation gradients would help distinguish seasonal variability from persistent range shifts. Such monitoring is especially important for endemic taxa and agricultural pests with rapidly changing distributions.

6. Recommended Methodological Framework for Future Field Studies

1. Stratify sampling by elevation, habitat type, land use and season.
2. Combine visual transects with sweep nets, pitfall traps, light traps, pheromone traps and host-plant inspection according to the target group.
3. Preserve voucher specimens and record GPS coordinates, altitude, habitat, host plant, collection date and collector.
4. Identify specimens using current taxonomic keys and curated reference collections.
5. Use DNA barcoding for cryptic, damaged or immature specimens and for confirmation of high-value records.

6. Record natural enemies and associated organisms during agricultural pest surveys.
7. Use standardized abundance and diversity indices so that results can be compared among regions and years.
8. Deposit validated records in institutional collections and biodiversity databases.

7. Limitations

This review is narrative and does not constitute a systematic review. Ethiopian entomological literature is unevenly distributed among insect orders, regions and habitats. Lepidoptera have a comparatively strong national synthesis, whereas equivalent national-level inventories for many other insect orders remain less complete. Consequently, the numerical results presented here should not be interpreted as a complete estimate of Ethiopia's total insect richness. In addition, agricultural pest literature often emphasizes economically important species and may underrepresent non-pest taxa.

8. Future Research Directions

Priority research should include a national, specimen-backed insect inventory; expanded sampling in poorly studied lowlands and montane habitats; DNA-barcode libraries linked to voucher specimens; and standardized monitoring of invasive agricultural pests. Research should also investigate host-plant associations, parasitoid and predator networks, phenology, climate-driven range shifts and insect responses to land-use change.

For agriculture, future studies should combine species identification with quantitative estimates of crop damage, economic thresholds, insecticide-resistance status and natural-enemy abundance. For conservation, repeated monitoring of endemic species and habitat specialists is needed to determine whether populations are stable, declining or shifting geographically.

9. Conclusion

Ethiopia possesses a highly diverse insect fauna shaped by exceptional environmental and topographic variation. The available Lepidoptera evidence alone documents 2,438 taxa in 48 families, including 664 endemic taxa [1], while recent local surveys continue to demonstrate substantial species richness [2]. At the same time, agricultural species such as Spodoptera frugiperda and diverse post-harvest pests create immediate economic challenges [3,4]. A national entomological strategy should therefore combine biodiversity inventory, agricultural surveillance, classical taxonomy, DNA-based identification, reference collections and ecological monitoring. Species-level knowledge is the foundation on which both insect conservation and sustainable pest management depend.

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